Experimental Investigation of the Water Mist Impacting Phenomenon on Horizontal Wires

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The phenomenon of water mist impacting on horizontal wires has been experimentally investigated. This process is relevant to the water mist intercepting and penetrating into the openings of compartment. The impaction of droplets on wires provides a basis for the understanding of the similar processes on more complicated structures such as screens, etc.

The mono-size water droplets are generated using the principle of Impulsed Spray Generator which was invented and patented by Yao and Ashgriz [1]. Figure 1 shows the cross-section schematic of this spray generator. It consists of a piezoelectric plate, a fluid chamber, and an orifice plate. The pressure pulses generated from the piezoelectric plate force the liquid jets to break up into mono-size droplets. Since any residual air bubbles trapped into the chamber would diminish the effect of pressure pulses, special inlet and exit channels of water flow are implemented in the generator for the bubbles to be swept away naturally.

The images of the impacting phenomenon are recorded using the strobe lighting, a CCD camera, and a video recorder. The CCD camera is equipped with stereomicroscopic lens for magnification.

Yao et al [2] studied the process of droplet impaction on rectangular strips. They illustrated that the controlling parameters of impacting phenomenon are the droplet Weber number (We_o), the offset of droplet relative to wire (Δ), and the ratio of incoming droplet diameter to the wire diameter (R) with the following definitions:

$$We_o = \frac{\rho_l V_o^2}{(\sigma/d)} \qquad \Delta = \frac{\delta}{(d+D)/2} \qquad R = \frac{d}{D}$$

where, d = diameter of droplet D = diameter of the wire
V_o = incoming droplet velocity ρ_l = density of droplet
δ = distance between the centers of the droplet and wire
σ = surface tension of the droplets

Generally, the impaction phenomenon consists of a combination of cutting, splashing, disintegrating, and regrouping. The diameters of shattered droplets usually appear as a spectrum with bimodal type distribution. Usually, the offset of the centers of the incoming droplet and the wire affects the result of impaction substantially. Figure 2 shows the typical images of this process. The incoming droplet Weber number is 47.4. The diameter of the wire is about 760 μm while the droplet diameter is about 600 μm (i.e., R= 0.789). As the droplets are approaching at a larger offset (i.e., Δ = 0.882) at the right side of the wire, a large fragment is formed on the right side while many small satellite droplets are disintegrated at the left side. At a smaller offset (Δ = 0.551), the droplet splits into 2 equally large segments, one at each side. However, when the droplet is approaching at zero offset (Δ = 0.0), it splashes onto the wire, warps around it, and then regroups together again to form a large elongated fragment of liquid. This fragment detaches from the wire and drips off downward vertically. It is expected that the corresponding phenomenon at higher Weber number could be different in nature.

Acknowledgment

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Reference

[1] Yao, S.C., and Ashgriz, N., "Multi-Orifice Impulsed Spray Generator," U.S. Patent Serial No. 4 667 877, 1986.

[2] Yao, S.C., Hochreiter, L.E., and Cai, K.Y., "Dynamics of Droplets Impacting on Thin Heated Strips," *J. Heat Transfer*, (**110**), pp. 214-220, 1988.

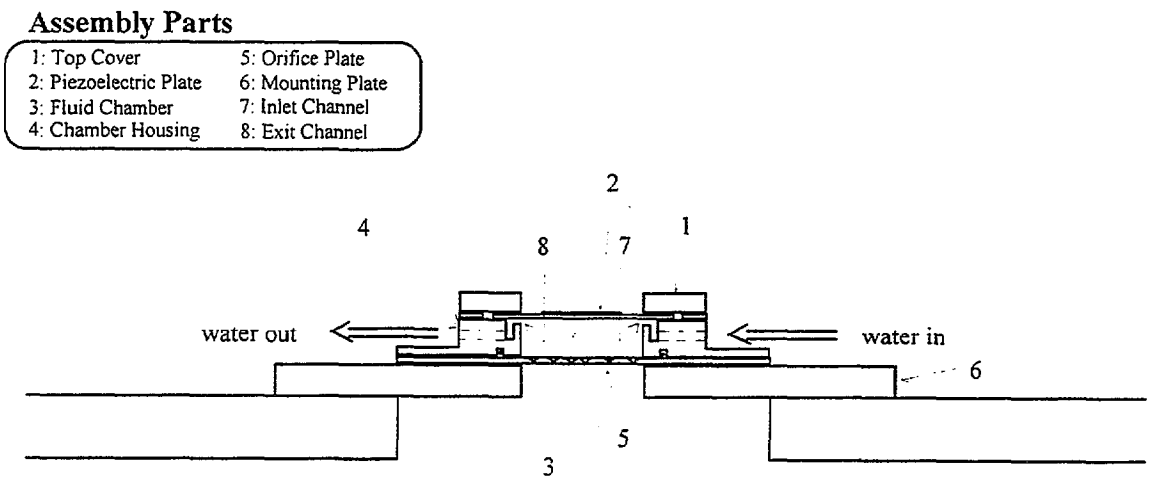
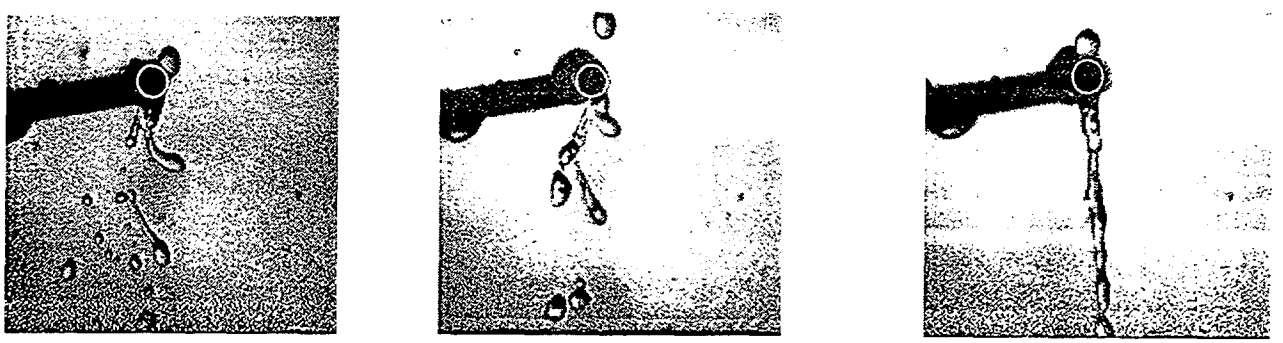


Figure 1 Schematic of the Impulsed Spray Generator (Cross Section)



(1) (2) (3)

Figure 2 Images of droplets impacting on the horizontal wire
(R = 0.789, We_o = 47.4)
(1) - Larger offset from the right side (Δ = 0.882)
(2) - Smaller offset from the right side (Δ = 0.551)
(3) - Zero offset (Δ = 0.0)